Royal Society of Biology Higher Education Bioscience Teacher of the Year 2021

Using videos and interactive simulations to enhance the learning experience

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Background

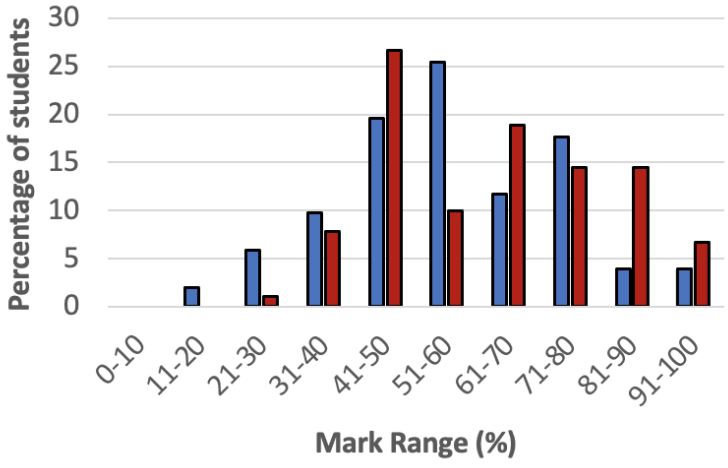
This case study illustrates the innovative approaches I have pioneered, using videos and interactive simulations to enhance the student learning experience, focusing particularly on laboratory teaching. With COVID-19 still disrupting teaching, forcing academics to explore novel approaches to engage students and provide meaningful lab-focussed teaching, videos present a way to capture students' imagination with this essential aspect of their bioscience education[1].

Rationale and benefits

Many students are digitally orientated, so using videos and interactive simulations has always been a central feature of my teaching[2], employing them throughout the learning cycle to enhance students' engagement with, and understanding of, laboratory-based classes. These include pre-lab videos, interactive simulations, live marking screencasts and workshops including videos of former students and interactive polls. These engaging media guide students' written skills and improve their feedback literacy, thereby maximising the benefits they received from our comments. These resources have proven far more engaging for students than previously printed lab guides and have improved student outcomes.

Videos for preparation

My pioneering use of videos started when I created a series of short screencasts for first-year students to teach molar calculations in parallel with the laboratory classes where they apply them. Previously, students had been taught via a traditional lecture-based approach, allowing little opportunity to interact with academics or clarify misconceptions[3]. The flipped approach introduced small-group tutorials with students voting on areas of confusion requiring additional support. This has evolved, inspired by Eric Mazur's approach, to include peer instruction and pair/small group work[4], tailoring the learning experience for each group. Overall, there was an associated increase in student performance (7.1%, $p<0.05$; t-test)(Fig.1) and student satisfaction, with module feedback scores increasing from 3.8/5 (5-year average) to 4.4/5 (3-year average) following the introduction of this flipped approach[5].



Year	N	Mean	SD
2017/18	51	55.96	17.5
2018/19	89	63.09	18.6

Figure 1: Mark distribution and summary statistics for students attempting the summative end of module online calculations assessment, comparing students taught by peer-instruction only (blue bars, 2017/18) and students taught using the flipped classroom methodology (red bars, 2018/19).

Having observed the power of flipped learning in the classroom, I applied the same principles directly to laboratory skills. Here, the purpose was to enhance student preparedness when

attending taught laboratory sessions in modules I co-ordinate, using Learning Science interactive simulations to replace a pre-lab quiz. I was the first academic to use these resources in Swansea University Medical School (SUMS), with student engagement being exceptionally high. Students revisiting the six available tools pre- and post-lab on average three times, highlighting their use for preparation and revision. Interestingly, female students made greater use of the resources (Fig.2a), showing a small but significant increase in performance compared to male peers (3.6%, $p<0.05$; t-test)(Fig.2b). Students who accessed one pre-lab resource made more use of subsequent resources ($p<0.005$; χ^2)(Fig.2c), with a survey showing that students felt increasingly comfortable working in the lab as a result of these simulations.

> "Pre-lab resources were very helpful in preparing me for classes, enabling me to practice techniques and understand how to use equipment. I felt much better prepared and more confident in the lab as a result."
>
> - Student, 2018

The study's results were disseminated at the 2019 Advance HE L&T Conference and as an invited speaker at Cardiff University, resulting in Cardiff's School of Biosciences adopting pre-lab simulations[6,7]. Learning Science resources have since been adopted across three additional undergraduate degree schemes in SUMS, and I act as a primary point of contact for departmental staff wishing to use these simulations.

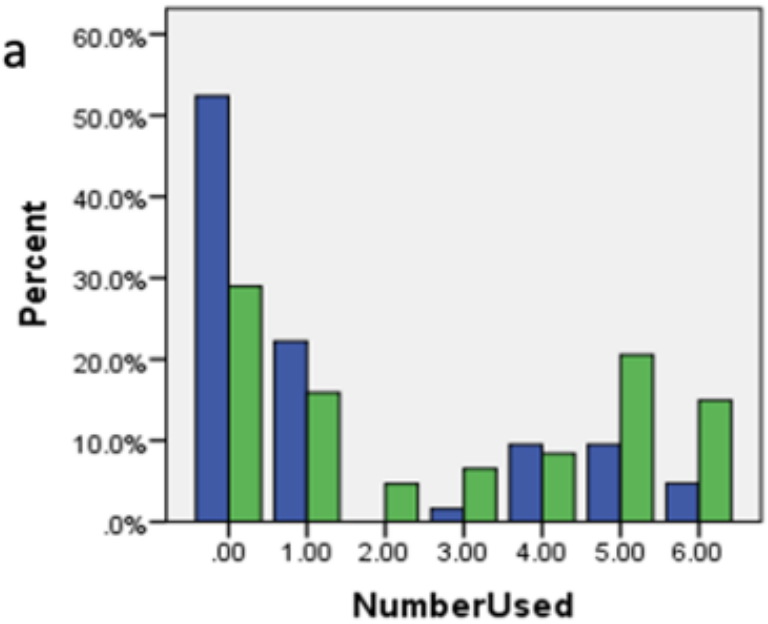
Videos for assessment and feedback

Videos can also enhance student engagement with feedback; following comments that assessment criteria for lab reports were not always clear, I created three live marking screencasts showing me marking mock practical reports in real-time while discussing the strengths and weaknesses of each against the marking rubric. These videos are used in conjunction with an interactive workshop teaching students about structuring lab reports at university. This allows students to get inside the mind of the marker, developing assessment literacy. This innovative use of video was presented to Dr Naomi Winstone (NTF, Director of the Surrey Institute of Education), who subsequently shared the screencasts with several thousand HE staff at Surrey and beyond, as best practice for using exemplars[8].

> "When I first saw Nigel's live-marking screencasts, I was instantly struck by their potential to catalyse the development of students' assessment literacy and their potential to create inclusive assessment practices and to 'demystify' assessment criteria."
>
> - Dr Naomi Winstone

In these workshops, I show videos of former students discussing the importance of feedback and how they made use of it during their studies. Current students in these sessions frequently highlight how beneficial the video interviews are to closing the learning cycle.

a



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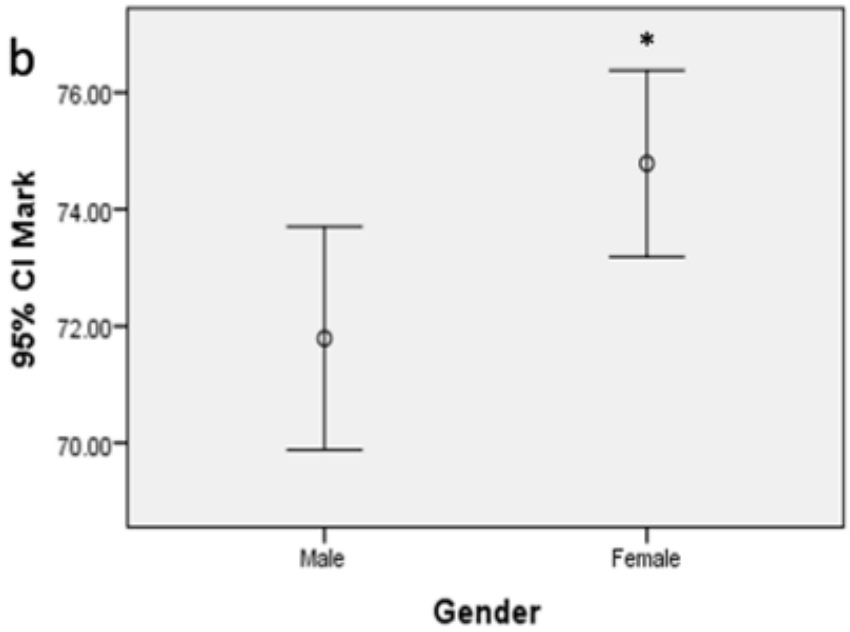

c

	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5	Simulation 6
Simulation 1	-	0.000 (+)	0.000 (+)	0.000 (+)	0.000 (+)	0.000 (+)
Simulation 2		-	0.000 (+)	0.000 (+)	0.000 (+)	0.000 (+)
Simulation 3			-	0.000 (+)	0.000 (+)	0.003 (+)
Simulation 4				-	0.000 (+)	0.005 (+)
Simulation 5					-	0.005 (+)
Simulation 6						-

Figure 2: (a) Bar graph illustrating percentage of students who accessed the six different pre-lab simulations (males – blue bars, females – green bars). (b) Box and whiskers plot displaying 95% confidence intervals around mean marks. (c) Students who accessed one resource were significantly more likely to access subsequent resources.

COVID-19 impacted teaching

One of the first challenges of moving teaching online at short notice was how to deliver sessions for ongoing assessments that would have been given face-to-face. At the time, I was running an enzyme kinetics lab, which included a data manipulation and analysis component. Unable to run the workshop that would typically accompany the class, I created a series of screencasts talking students through how to analyse their data using Excel; these three videos have a global audience on YouTube, receiving over 10,900 views since March 2020.

I was at the forefront of the bioscience sector's response to providing meaningful laboratory experiences when COVID-19 forced universities to close their physical doors. Capitalising on my experience of using videos for education, I established the #DryLabsRealScience network[9,10]. This collaborative network has created a community of academics from over 70 HEIs, with the videos of talks made freely available via YouTube and the lectuREmotely website.

Figure 3: Selection of talks from #DryLabsRealScience and lectuREmotely website resources page.

Collectively, over 9,800 person-hours have been invested by attendees at the nine webinars to date, while the videos have received over 1,800 views on YouTube, with the lectuREmotely website recording over 13,500 hits from over 30 countries across six continents, highlighting the global influence of this network.

> "#DryLabsRealScience has directly facilitated the successful delivery of a range of alternative lab provisions and capstone projects. The network has acted as a springboard for Early Career Lecturers, giving them a platform to present their work and ideas."
>
> - Dr David Smith, SHU

Innovation during COVID-19

Inspired by #DryLabsRealScience, I produced in-house videos demonstrating the correct use of laboratory equipment, with these videos embedded alongside accompanying Learning Science resources to support face-to-face teaching by maximising the students' theoretical

understanding of techniques before even being in the lab. Videos with deliberate mistakes were also created and used as part of a formative, 'light touch' quiz that students need to complete before being able to access the practical instructions and assessment. The benefit of this combined approach, which will be retained after the pandemic, is that students interact with professionally produced simulations[2] before viewing videos of the staff members they will see in the lab demonstrating the correct usage of the precise equipment they will be using. Evidence from technical staff and postgraduate demonstrators shows that students have a far better understanding of how to use equipment, with less 'how do I use this?' and more 'what does this mean?' type questions being asked. There has been an associated reduction in students finishing the class without generating sufficient data to complete their assignments compared to previous years, highlighting the impact of these interactive video resources. The videos have been shared via a public-facing Canvas course, which allows academics to download the resources and embed them in their own institution's VLE.

The resources I produce are often co-created with student partners, including the Immunology Wars website and a virtual flow cytometer, developed in collaboration with an in-house learning technologist to replace a second-year practical workshop. This simulation allows students to interact with and explore the different parts of a flow cytometer before designing a short experiment in preparation for an assessed interactive quiz, requiring the interpretation of flow cytometry dot plots to diagnose a group of patients based on their clinical presentations. The assessment, which tests application of knowledge rather than pure recall, discriminates students well at low and intermediate levels with a broader range of the mark scheme used compared to an accompanying MCQ assessment.

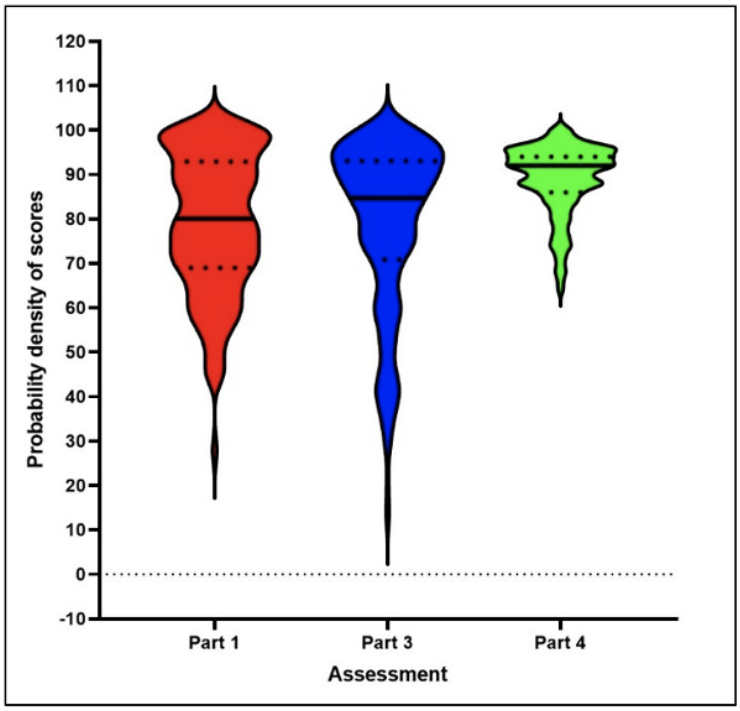

Figure 4: Violin plot of student scores in the virtual flow cytometer assessment (Parts 1 and 3) compared to traditional MCQ testing (Part 4) (N.B. Part 2 not assessed). The violin plot presents the data as a probability density, smoothed by a kernel density estimator, resulting in better estimates of distributions than box and whisker plots. Bold horizontal black line represents the median value. Dotted lines represent the high and low quartiles and interquartile range.

Student feedback has been extremely positive, with many mentioning the immersive experience that allowed them to gain a better appreciation of the intricacies of the technique.

> "I appreciate the online-practical content, such as the flow cytometry experiment. I encourage staff to produce and release more of these supporting materials since I felt I gained insight into what (*it*) would have been (*like*) to carry out the experiment in the lab."
>
> \- Student, 2020

Conclusions and opportunities

Videos and simulation can be used at all stages of the learning cycle, allowing students to engage with the resources at a time and place that suits them. However, careful consideration needs to be made to ensure that students can access teaching materials. Some students may not be digital natives, requiring additional support, while accessibility issues also need to be considered. Perhaps most importantly, while a majority of students' learning is taking place online, there is a real risk of online fatigue; videos and simulations should be used to support and enhance the face-to-face interactions that, it is clear, our students value so deeply.

The current global pandemic threw HE teaching into disarray; many teachers and students initially struggled to transition to the new online/blended approach; however, through my innovative use of videos, I have influenced my peers' practice, allowing their students to thrive and continue learning. In the words of Yoda…

Word count: 1538 excluding figure legends.

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